



Department of Commerce

Safety & Buildings Division

201 West Washington Avenue

P.O. Box 2658

Madison, WI 53701-2658

Evaluation # 200215-R

Wisconsin Building Products Evaluation

Material

Pentstar Concrete Form Masonry Unit CFMU
Concrete/Masonry Building System

Manufacturer

Pentstar Corporation
7308 Aspen Ln #114
Minneapolis, MN 55428

SCOPE OF EVALUATION

GENERAL: This report evaluates the use of Pentstar Concrete Form Masonry Units through a review of structural performance, interior finish, fire-resistance (equivalent thickness of the masonry core only), surface-burning characteristics and thermal performance of the foam core.

This review includes the cited **Comm** code section requirements below in accordance with the current **Wisconsin Building and Heating, Ventilating and Air Conditioning Code**:

- **Structural:** The Pentstar Concrete Form Masonry Units were evaluated as structural components of a masonry wall in accordance with **ss. Comm 53.10**, and **53.30**.
- **Interior Finish:** When the interior face of the Pentstar Concrete Form Masonry Units is other than masonry, face brick, etc. the interior finish material shall meet the requirements of **s. Comm 51.07**.
- **Fire-Resistance:** The Pentstar Concrete Form Masonry Units were evaluated as components of a rated wall assembly in accordance with **s. Comm 51.043** and **s. Comm 51.045**.
- **Foam Plastic Core Component:** The foam plastics used within the wythe of the Pentstar Concrete Form Masonry Units is identified as TUFF-R Insulating Sheathing, produced by Celotex Corporation, and CertiFoam 15 (extruded polystyrene), and RayLite (expanded polystyrene), produced by Diversifoam Products, Inc. The TUFF-R Insulating Sheathing and Diversifoam products were evaluated under the foam plastic requirements in accordance with **s. Comm 51.06(2)**.
- **Thermal Performance of Foam Core:** The TUFF-R Insulating Sheathing was evaluated for use as an insulation material with specified "R" values. The "R" values may be used in heat gain and heat loss calculations as required by **ss. Comm 63.14** through **63.18**. Also, see **Wisconsin Building Product Evaluation # 200076-I** for additional information on Celotex's TUFF-R Insulating Sheathing.

The Diversifoam products were also evaluated for use as an insulation material with specified "R" values. The "R" values may be used in heat gain and heat loss calculations as required by **ss. Comm 63.14** through **63.18**.

The "R" value for the assembly involving the use of the Pentstar Concrete Form Masonry Unit and Tuff-R Insulating Sheathing, and Diversifoam products located in the cores shall be based on the requirements of **s. Comm 63.1018(2)(c)**. See **TESTS AND RESULTS** section of this evaluation for specific R-values.

This review includes the cited **International Building Code (IBC)** requirements below in accordance with the **Wisconsin Amended IBC 2000 Code (effective 7/1/02)**:

- **Structural**: The Pentstar Concrete Form Masonry Units were evaluated as structural components of a masonry wall in accordance with **ss. IBC 2103.1** through **2103.4**, **2103.7**, **2103.9.8**, **2103.10** through **IBC 2103.11.6**, **2104.1** through **IBC 2104.1.3**, **2105**, **2107**, **2108**, and **2109**.
- **Interior Finish**: When the interior face of the Pentstar Concrete Form Masonry Units is other than masonry, face brick, etc. the interior finish material shall meet the requirements of **s. IBC 803**.
- **Fire-Resistance**: The Pentstar Concrete Form Masonry Units were evaluated as components of a rated wall assembly in accordance with **ss. IBC 720.1**, **720.2** through **IBC 720.2.1.4.5**, **720.3** through **IBC 720.3.1.1**, **720.3.1.3** and **720.3.2** through **IBC 720.4**.
- **Foam Plastic Core Component**: The foam plastics used within the wythe of the Pentstar Concrete Form Masonry Units is identified as TUFF-R Insulating Sheathing, produced by Celotex Corporation, and CertiFoam 15 (extruded polystyrene), and RayLite (expanded polystyrene), produced by Diversifoam Products, Inc. The TUFF-R Insulating Sheathing and Diversifoam products were evaluated under the foam plastic requirements in accordance with **ss. IBC 2603.1**, **2603.2**, **2603.3**.
- **Thermal Performance of Foam Core**: The TUFF-R Insulating Sheathing was evaluated for use as an insulation material with specified "R" values. The "R" values may be used in heat gain and heat loss calculations as required by **s. IBC 1301.1** and **s. IBC 1301.1.1**. Also, see **Wisconsin Building Product Evaluation # 200076-I** for additional information on Celotex's TUFF-R Insulating Sheathing.

The Diversifoam products were also evaluated for use as an insulation material with specified "R" values. The "R" values may be used in heat gain and heat loss calculations as required by **ss. Comm 63.14** through **63.18**.

The "R" value for the assembly involving the use of the Pentstar Concrete Form Masonry Unit and Tuff-R Insulating Sheathing, and Diversifoam products located in the cores shall be based on the requirements of **s. Comm 63.1018(2)(c)**. See **TESTS AND RESULTS** section of this evaluation for specific R-values.

DESCRIPTION AND USE

General: The Pentstar Concrete Form Masonry Units (CFMU), consists of a exterior face shell, 1-inch weep cavity, insulation insert, grout cavity, plastic connector, plastic end connector, plastic spacers and interior face shell.

The exterior face shells utilize variety of material including concrete block, clay brick, quarried stone, and faux concrete and stone products. These materials are available in a multitude of colors, textures and design patterns.

The insulation insert (TUFF-R), is a rigid polyisocyanurate foam board with a triple layer of protective faces (foil-kraft-foil) on the weather side and one layer of solid aluminum foil on the other side. Thickness range from ¾-inch to 2-inches.

The insulation insert (CertiFoam 15) is a rigid extruded polystyrene foam board. Thickness range from 1-inch to 2-inches.

The insulation insert (RayLite) is a rigid expanded polystyrene foam board. Thickness range from 1-inch to 2-inches.

After a CFMU wall has been laid to a height of 8 to 12 feet, the interior cavity is filled with concrete grout and the required reinforcement. **Note: CFMU cells should be filled solidly in grout lifts not to exceed 12 feet.**

The interior face shells utilize variety of material including concrete block, clay brick, quarried stone, and faux concrete and stone products. These materials are available in a multitude of colors, textures and design patterns.

The face shells are fed into an assembly machine where the plastic connectors are snapped into place, creating the completed unit. A cross section of a typical 12" CFMU unit consists of a 1-5/8" to 2-1/4" thick exterior face shell; a 1-inch air/weep cavity, a 2" thick rigid insulation panel; a 5-3/4" concrete grout cavity, a 1-5/8" to 2-1/4" thick interior face shell. The union of the grout with the interior face shell creates a solid concrete structural member that is 7-1/4" to 8-1/8" thick, and is designed to incorporate a wide variety of reinforcing options. See Figure 1.

The completed CFMU can be laid in different bond patterns, including running, common, Flemish and stack bond, as well as in modular and Ashlar stone patterns. See Figure 2 for examples.

The plastic connectors and spacers are made from 100% recycled polymers.

Figure 1 Pentstar Concrete Form Masonry Unit

The Pentstar system depends on two key structural components: first mortar to bond the units together and second, reinforced concrete grout to provide load-bearing integrity. The mortar applied to the Pentstar units is installed just as traditional masonry. It is recommended that installers use a type N mortar. Full double buttered head joints are required to resist moisture penetration and should be no less than the thickness of the block face shell.

As the units are installed, horizontal and vertical steel reinforcement is placed in the grout cavity. Pentstar uses a positioning system for steel reinforcement. Each plastic connector is made with rebar chairs for horizontal reinforcement, and positioning stirrups for vertical steel. Spacing of horizontal and vertical reinforcement shall be determined by either prescriptive design tables or by a licensed professional engineer or architect using reinforced concrete masonry design standards.

For unit block configurations and construction details, refer to the Pentstar Concrete Form Masonry Units Installation and Construction Manual.

Figure 2 Pentstar Bonding Patterns**TESTS AND RESULTS**

The tests and results listed below cover both the current WI Building Code **Comm** and future **IBC** requirements.

Structural: The concrete block units meet the load bearing compressive strength requirements. Testing of the CFMU wall panels at the National Concrete Masonry Association's test lab facility in Herndon, Virginia revealed that the 12" CFMU wall panels (with the resulting 7" concrete mass), were as strong as a comparable cast-in-place concrete wall.

The CFMU used in the test panel had the following material properties (based on tests, as per ASTM C90, C140 and C426):

Unit Compressive strength (psi).....	5100
Absorption (pcf).....	8.9
Density of face shells (pcf).....	131.1
Linear Drying Shrinkage (%).....	0.031
Mortar Compressive Strength (type S pcl)(psi).....	3253 – 3457
Grout Compressive Strength (psi).....	3520 – 3610
Grout Slump (in.).....	10
Masonry Prism Compressive Strength (F'm)	
UngROUTED (psi).....	3247
Grouted (psi).....	2821

Unreinforced CFMU: Calculated, via allowable stress, maximum axial load values for a 11-5/8" CFMU wall panel (with the standard 7" structural member) based upon 1.5" of eccentricity from the centroid of the structural section to point of load application; axial loading only – no lateral loads.

Maximum Axial Load Per Foot For Unreinforced Wall^{1,2}

Wall Height	Masonry Compressive Strength, f'_m				
	1,000	1,500	2,000	2,500	3,000
6 ft.	10,330	15,490	20,650	25,820	30,980
8 ft.	10,030	15,040	20,050	25,060	30,080
10 ft.	9,620	14,420	19,230	24,040	28,850
12 ft.	6,860	10,290	13,720	17,140	20,570
14 ft.	5,040	7,560	10,080	12,600	15,120
16 ft.	3,860	5,790	7,710	9,640	11,570
18 ft.	3,050	4,570	6,100	7,620	9,140
20 ft.	2,470	3,700	4,940	6,170	7,410
22 ft.	2,040	3,060	4,080	5,100	6,120
24 ft.	1,710	2,570	3,430	4,290	5,140
26 ft.	1,460	2,190	2,920	3,650	4,380

Notes: 1 – 4-inch bearing assumed, provided 1.5-inch eccentricity from the centroid of the structural section to point of load application.

2 – Axial loading only, no lateral loads included. The application of lateral loading will reduce the allowable axial load.

Flexural Tension: For unreinforced masonry, flexural tension is limited in walls by the allowable stresses given in the code. For fully grouted concrete masonry, the allowable stresses are as shown in the table below:

Allowable Flexural Tension in Fully Grouted Concrete Masonry, psi

Masonry Type	Mortar Type			
	Portland cement/lime or mortar cement		Masonry cement or air entrained Portland cement/lime	
	M or S	N	M or S	N
Normal to bed joints fully grouted	68	58	41	29
Parallel to bed joints in running bond fully grouted	80	60	48	30

Non-Loadbearing Wall Height Table: For walls that have negligible axial applied loading, the wall heights permitted depend on mortar type and wind pressure. The table below gives the maximum wall heights for various wind loads for each mortar type:

Maximum Wall Heights ^{1,2}				
Wind Pressure	Mortar Type			
	Portland Cement Lime		Masonry Cement	
	M or S	N	M or S	N
10	26' - 4"	22' - 8"	20' - 4"	16' - 0"
20	18' - 8"	16' - 0"	14' - 4"	11' - 4"
25	16' - 8"	14' - 4"	13' - 0"	10' - 0"
30	15' - 0"	13' - 0"	11' - 8"	9' - 4"
35	14' - 0"	12' - 0"	10' - 8"	8' - 4"
40	13' - 0"	11' - 4"	10' - 0"	8' - 0"

Notes: 1 – Assumes a simple span with pinned ends.
2 – 1/3 allowable stress increase for wind.

Reinforced Masonry: Reinforced masonry design by the “working stress” method is covered by Section 2.3 of the ACI 530 Code. This analysis procedure neglects the tensile strength of the masonry and, therefore, relies completely on steel reinforcement to resist tensile stresses.

The allowable stresses for reinforced design are as follows:

Tension – Tensile stress in reinforcement shall not exceed the following:

- (a) Grade 40 or Grade 50 reinforcement.....20,000 psi
- (b) Grade 60 reinforcement.....24,000 psi
- (c) Wire joint reinforcement.....30,000 psi

Compression – The compressive resistance of steel reinforcement shall be neglected unless lateral reinforcement is provided in compliance with the requirements of Section 2.1.4.6 of the ACI 530 Code.

Compressive stress in reinforcement shall not exceed the lesser of $0.4 f_y$ or 24,000 psi.

Plastic Connectors and Spacers: The plastic connectors and spacers are made from 100% recycled polymers, manufactured by Entec Polymers, Inc. Underwriter’s Laboratories, Inc., tested the material N1233HL or, Polyamide 66 (PA66), in pellet form. The test was in accordance with UL94 Small-Scale Test. Underwriter’s Laboratories, Inc. has rated the material N1233HL or, Polyamide 66 (PA66), with an HB Classification. Thermal testing in accordance with ASTM D648 was also done. Mechanical testing in accordance with ASTM D638 and ASTM D790 was also done.

Thermal Performance of Foam Core: The "R" values specified in this evaluation (TUFF-R Insulation Sheathing), were determined in accordance with ASTM C518 Standard Test Method. Boards were aged for 90 days at 140° F prior to testing. The following R-Values have been determined for aged TUFF-R Insulation Sheathing and may be used in heat loss calculations required by ss. **Comm 63.18, IBC 1301.1** and **IBC 1301.1.1**, respectively. *Note: All R-Values are aged TUFF-R Insulation Board at 75° F mean temperature.

<u>Thickness</u>	<u>R-Value*</u>	<u>Thickness</u>	<u>R-Value*</u>
¾-inch.....	5.8	1-1/2-inch.....	11.5
1-inch.....	7.7	1-3/4-inch.....	13.5
1-1/4-inch.....	10.0	2-inch.....	15.4

Thermal mass calculations, using methods acceptable to the department, may be submitted for review for specific projects.

Testing in accordance with ASTM E514, “Standard Test Method for Water Penetration and Leakage Through Masonry”, was conducted at the NCMA lab in Herndon, Virginia was conducted to determine the water penetration resistance of the Pentstar wall system.

The "R" values specified in this evaluation (CertiFoam 15 and RayLite), were determined in accordance with ASTM C518 and ASTM C177 Standard Test Methods. Boards were aged for 90 days at 140° F prior to testing. The following R-Values have been determined for aged CertiFoam 15 and RayLite may be used in heat loss calculations required by ss. **Comm 63.18, IBC 1301.1** and **IBC 1301.1.1**, respectively. *Note: All R-Values are aged CertiFoam 15 and RayLite Board at 75° F mean temperature.

CertiFoam 15:	<u>Thickness</u>	<u>R-Value*</u>	RayLite:	<u>Thickness</u>	<u>R-Value*</u>
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1-inch.....	5.0	1-inch.....	4.17
1-1/2-inch.....	7.5	1-1/2-inch.....	6.26
2-inch.....	10.0	2-inch.....	8.34

Thermal mass calculations, using methods acceptable to the department, may be submitted for review for specific projects.

LIMITATIONS OF APPROVAL

Building Code Applicable to Projects Submitted for Review Prior to July 1, 2002: The **Comm** limitations below are in accordance with the current **Wisconsin Building and Heating, Ventilating and Air Conditioning Code**:

Structural:

- Pentstar Concrete Form Masonry Units are approved as structural building elements in accordance with **ss. Comm 53.10, and 53.30**.
- Pentstar Concrete Form Masonry Units are approved for walls when structural calculations are submitted, by a Wisconsin registered professional engineer or architect. **Note:** All rebar placement requires stamped and signed specifications and construction plan/details. Minimum reinforcement for walls shall conform to **s. Comm 53.316**. All steel reinforcement must be in place and inspected before grouting.
- Walls shall be anchored to all floors and roofs. Walls shall be interconnected at corners by embedding and lapping the reinforcement.
- All concrete grout fill shall be a mixture of sand, water, Portland lime cement and gravel or crushed stone. Field slump, concrete fill procedures, mechanical vibration or rodding, etc., shall be in accordance with **Chapter 53, and ACI-318**.

Interior Finish:

- When the interior face of the Pentstar Concrete Form Masonry Units is other than masonry, face brick, etc. the interior finish material shall meet the requirements of **s. Comm 51.07**.
- The foam plastic used within the wythe of the Pentstar Concrete Form Masonry Units was evaluated for compliance with the thermal requirements of **s. Comm 63.18**. See **TESTS AND RESULTS** section for specific R-Values.

Fire-Resistance:

- The masonry core of the Pentstar Concrete Form Masonry Units can be used to establish the fire-resistance rating of the wall assembly in accordance with **s. Comm 51.043 and s. Comm 51.045**. **Note:** Equivalent thickness of the masonry core only shall be calculated.

Foam Plastic Core Component:

- The foam plastic used within the wythe of the Pentstar Concrete Form Masonry Units is identified as TUFF-R Insulating Sheathing, produced by Celotex Corporation. Also, see **Wisconsin Building Product Evaluation No. 200076-I** for additional information on Celotex's TUFF-R Insulating Sheathing.

Thermal Performance of Foam Core:

- The TUFF-R Insulating Sheathing, and the Diversifoam products (CertiFoam 15 and RayLite), are identified as the insulation materials with specified "R" values. The "R" values may be used in heat gain and heat loss calculations as required by **ss. Comm 63.14 through 63.18**.
- The assembled R-Value of the units/wall shall be based on the Isothermal Planes calculation method (series-parallel), as specified by the "American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals".

NOTE: Insulation other than TUFF-R Insulation Sheathing shall require third party test data determining the R-Value, or the R-Values from the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals, shall be used in the submitted calculations.

- The "R" value for the assembly involving the use of the Pentstar Concrete Form Masonry Unit, Tuff-R Insulating Sheathing and the Diversifoam products (CertiFoam 15 and RayLite), located in the cores shall be based on the requirements of **s. Comm 63.1018(2)(c)**. See **TESTS AND RESULTS** section of this evaluation for specific R-values.

The **IBC** limitations below are in accordance with the **Wisconsin Amended IBC 2000 Code (effective 7/1/02)**:

Structural:

- Pentstar Concrete Form Masonry Units are approved as structural building elements in accordance with **ss. IBC 2103.1 through IBC 2103.4, 2103.7, 2103.9.8, 2103.10 through IBC 2103.11.6, 2104.1 through IBC 2104.1.3, 2105, 2107, 2108, and 2109.**
- Pentstar Concrete Form Masonry Units are approved for walls when structural calculations are submitted, by a Wisconsin registered professional engineer or architect. **Note:** All rebar placement requires stamped and signed specifications and construction plan/details. Minimum reinforcement for walls shall conform to **s. IBC 2108.9.2**. All steel reinforcement must be in place and inspected before grouting.
- Walls shall be anchored to all floors and roofs. Walls shall be interconnected at corners by embedding and lapping the reinforcement.
- All concrete grout fill shall be a mixture of sand, water, Portland lime cement and gravel or crushed stone. Field slump, concrete fill procedures, mechanical vibration or rodding, etc., shall be in accordance with **ss. IBC 2103.9.8, 2103.10 and ACI-318.**

Interior Finish:

- When the interior face of the Pentstar Concrete Form Masonry Units is other than masonry, face brick, etc. the interior finish material shall meet the requirements of **s. IBC 803.**

Fire-Resistance:

- The masonry core of the Pentstar Concrete Form Masonry Units can be used to establish the fire-resistance rating of the wall assembly in accordance with **ss. IBC 720.1, 720.2 through IBC 720.2.1.4.5, 720.3 through IBC 720.3.1.1, 720.3.1.3 and s. IBC 720.3.2 through IBC 720.4.** **Note:** Equivalent thickness of the masonry core only.

Foam Plastic Core Component:

- The foam plastic used within the wythe of the Pentstar Concrete Form Masonry Units is identified as TUFF-R Insulating Sheathing, produced by Celotex Corporation. The TUFF-R Insulating Sheathing.

Thermal Performance of Foam Core:

- The TUFF-R Insulating Sheathing and the Diversifoam products (CertiFoam 15 and RayLite), are identified as the insulation materials with specified "R" values. The "R" values may be used in heat gain and heat loss calculations as required by **s. IBC 1301.1 and s. IBC 1301.1.1.**
- The assembled R-Value of the units/wall shall be based on the Isothermal Planes calculation method (series-parallel), as specified by the "American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals".

NOTE: Insulation other than TUFF-R Insulation Sheathing shall require third party test data determining the R-Value, or the R-Values from the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Handbook of Fundamentals, shall be used in the submitted calculations.

- The "R" value for the assembly involving the use of the Pentstar Concrete Form Masonry Unit, Tuff-R Insulating Sheathing and the Diversifoam products (CertiFoam 15 and RayLite), located in the cores shall be based on the requirements of **s. Comm 63.1018(2)(c)**. See **TESTS AND RESULTS** section of this evaluation for specific R-values.

Pentstar Concrete Form Masonry Units shall be installed in accordance with the manufacturer's installation instructions/manual and the requirements included in this evaluation.

This approval will be valid through December 31, 2007, unless manufacturing modifications are made to the product or a re-examination is deemed necessary by the department. The Wisconsin Building Product Evaluation number must be provided when plans that include this product are submitted for review.

DISCLAIMER

The department is in no way endorsing or advertising this product. This approval addresses only the specified applications for the product and does not waive any code requirement not specified in this document.

Revision Date:

Approval Date: April 8, 2002

By: _____

Lee E. Finley, Jr.

Product & Material Review
Integrated Services Bureau

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